TITLE

MANUFACTURING METHOD FOR AN ELECTRON-EMITTING SOURCE OF TRIODE STRUCTURE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to a manufacturing method for an electron-emitting source. In particular, the present invention relates to a manufacturing method for an electron-emitting source of triode structure.

Description of the Related Art

The method of manufacturing an electron-emitting source using carbon nanotubes (CNT) as an emitter is already widely used in the field of FED (field emission display) diode structure. However, in the field of the CNT-FED of triode structure, it is very difficult to coat the CNT on the negative electrode because the gate hole in the above triode structure is smaller than 100 μm. Therefore, it is very important to find an improved method to accurately coat the CNT on negative electrode.

SUMMARY OF THE INVENTION

The present invention is intended to overcome the above-described disadvantages.

Therefore, the first object of the present invention is to provide a manufacturing method for an electron-emitting source of triode structure, comprising the steps of forming a cathode

layer on a substrate, forming a dielectric layer on the cathode layer, and positioning an opening in the dielectric layer to expose the cathode layer wherein the opening has a surrounding region and forming a gate layer on the dielectric layer, except on the surrounding region, forming a hydrophilic layer in the opening, forming a hydrophobic layer on the gate layer and the surrounding region wherein the hydrophobic layer contacts the ends of the hydrophilic layer, dispersing a carbon nanotube solution on the hydrophilic layer using ink jet printing; and executing a thermal process step, and removing the hydrophobic layer.

According to the present invention as described above, carbon nanotubes are accurately deposited over a large area using ink jet printing.

The second object of the present invention is to provide a manufacturing method for an electron-emitting source of triode structure, comprising the steps of forming a cathode layer on a substrate, forming a dielectric layer on the cathode layer, and positioning an opening in the dielectric layer to expose the cathode layer, wherein the opening has a surrounding region, forming a gate layer on the dielectric layer, except on the surrounding region, forming a sacrificial layer on the gate layer and the surrounding region, wherein the opening and the cathode layer are exposed, dispersing a carbon nanotube solution in the opening using screen printing, executing a thermal process step, and removing the sacrificial layer.

According to the present invention as described above, carbon nanotubes are successfully deposited over a large area using screen printing.

The third object of the present invention is to provide a manufacturing method for an electron-emitting source of triode structure, comprising the steps of forming a cathode layer on a substrate, forming a dielectric layer on the cathode layer, and positioning an opening in the dielectric layer to expose the cathode layer, wherein the opening has a surrounding region, forming a gate layer on the dielectric layer, except on the surrounding region, forming a carbon nanotube photoresist layer on the gate layer and covering the opening using spin coating, and patterning the carbon nanotubes photoresist layer in a predetermined pattern, and executing a thermal process step.

According to the present invention as described above, carbon nanotubes are successfully deposited over a large area using spin coating.

The fourth object of the present invention is to provide a manufacturing method for an electron-emitting source of triode structure, comprising the steps of forming a cathode layer on a substrate forming a dielectric layer on the cathode layer, and positioning an opening in the dielectric layer to expose the cathode layer, wherein the opening has a surrounding region, forming a gate layer on the dielectric layer, except on the surrounding region, forming a sacrificial layer on the gate layer and the surrounding region, wherein the opening is exposed, forming an adhesive layer in the opening, forming a carbon nanotube layer on the adhesive layer using an electrophoretic deposition step, executing a thermal process step, and removing the sacrificial layer.

According to the present invention as described above, carbon nanotubes are accurately deposited over a large area using electrophoretic deposition (EPD).

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more fully understood by reading the subsequent detailed description in conjunction with the examples and references made to the accompanying drawings, wherein:

Figs. 1a to 1h are sectional views showing a process for manufacturing an electron-emitting source of triode structure in accordance with embodiment 1 of the present invention;

Figs. 2a to 2h are sectional views showing a process for manufacturing an electron-emitting source of triode structure in accordance with embodiment 2 of the present invention;

Figs. 3a to 3h are sectional views showing a process for manufacturing an electron-emitting source of triode structure in accordance with embodiment 3 of the present invention;

Figs. 4a to 4g are sectional views showing a process for manufacturing an electron-emitting source of triode structure in accordance with embodiment 4 of the present invention; and

Figs. 5a to 5c are sectional views showing cathode electrophoretic deposition, anode electrophoretic deposition, and suspensing electrophoretic deposition respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiment 1

Figs. 1a to 1h are sectional views showing a process for manufacturing an electron-emitting source of triode structure using ink jet printing.

First, as shown in Fig 1a, a substrate **10** is provided. Secondly, as shown in Fig 1b, a cathode layer **12** is deposited on the substrate **10**. Further, as shown in Fig 1c, a dielectric

layer **14** is deposited on the cathode layer **12**, and an opening **13** is positioned in the dielectric layer **14** to expose the cathode layer **12**, wherein the opening **13** has a surrounding region **15**. Furthermore, as shown in Fig 1d, a gate layer **16** is deposited on the dielectric layer **14** except the surrounding region **15**. a gate hole **17** is formed after depositing the gate layer **16**.

As shown in Fig 1e, a hydrophilic layer **18** is deposited in the gate hole **17**. Because the hydrophilic layer **18** absorbs the water of a carbon nanotube solution used in this embodiment, it successfully prevents the CNT solution from overflowing the gate hole **17**.

As shown in Fig 1f, a hydrophobic layer **20** is deposited on the surface of the gate layer **16** and the surrounding region **15**, wherein the hydrophobic layer **20** contacts the ends of the hydrophilic layer **18**. Because the hydrophobic layer **20** defines the position where CNT solution formed on the cathode layer **12** and prevents CNT solution from being absorbed into the sidewalls of the gate hole **17**, it successfully solves the leakage current or short problems caused by the residue of the CNT solution between the cathode layer **12** and the gate layer **16** after thermal process step.

As shown in Fig 1g, a CNT solution **22** is dispersed on the hydrophilic layer **18** using ink jet printing. Finally, a thermal process step is executed, and the hydrophobic layer **20** is removed to form a CNT emitter **24**, as shown in Fig 1h.

As mentioned above, according to embodiment 1 of the present invention, carbon nanotubes are accurately deposited over a large area using ink jet printing, and an electron-emitting source of triode structure having good properties, and used as CNT-FED, is obtained.

The substrate **10** is preferably made of glass. The cathode layer **12** or the gate layer **16** is preferably composed of electric conductors such as silver. The hydrophobic layer **20** is preferably composed of hydrophobic materials such as hydrophobic photoresist. The above thermal process preferably adopts a sintering step.

Embodiment 2

Figs. 2a to 2h are sectional views showing a process for manufacturing an electron-emitting source of triode structure using screen printing.

First, as shown in Fig 2a, a substrate **30** is provided. Secondly, as shown in Fig 2b, a cathode layer **32** is deposited on the substrate **30**. Further, as shown in Fig 2c, a dielectric layer **34** is deposited on the cathode layer **32**, and an opening **33** is positioned in the dielectric layer **34** to expose the cathode layer **32**, wherein the opening **33** has a surrounding region **35**. Furthermore, as shown in Fig 2d, a gate layer **36** is deposited on the dielectric layer **34** except the surrounding region **35**. a gate hole **37** is formed after depositing the gate layer **36**.

As shown in Fig 2e, a sacrificial layer **38** is deposited on the surface of the gate layer **36** and the surrounding region **35**, wherein the gate hole **37** and the cathode layer **32** are exposed. Because the sacrificial layer **38** defines the position where the CNT solution is formed on the cathode layer **32**, and prevents CNT solution from being absorbed into the sidewalls of the gate hole **37** or the surface of the gate layer **36**, it successfully solves the leakage current or short problems caused by the residue of the CNT solution on the cathode layer **32** or the gate layer **36** after thermal process step.

As shown in Fig 2f, a CNT solution **40** is dispersed on the gate hole **37** by screen mask **42** using screen printing. At this time, some residue **43** of the above CNT solution is dropped on the surface of the sacrificial layer **38**. In this case, the residue **43** is removed using a polish step, as shown in Fig 2g. Finally, a thermal process step is executed, and the sacrificial layer **38** is removed to form a CNT emitter **44**, as shown in Fig 2h.

As mentioned above, according to embodiment 2 of the present invention, carbon nanotubes are accurately deposited over a large area using screen printing, and an electron-emitting source of triode structure having good properties, and used as CNT-FED, is obtained.

The substrate **30** is preferably made of glass. The cathode layer **32** or the gate layer **36** is preferably composed of electric conductors such as silver. The sacrificial layer **38** is preferably composed of photosensitive materials such as photoresists, peelable materials such as hydrophilic materials and lipophilic materials, soluble materials, sinterable materials, or etchable materials. The above thermal process preferably adopts a sintering step.

<u>Embodiment 3</u>

Figs. 3a to 3h are sectional views showing a process for manufacturing an electron-emitting source of triode structure using spin coating.

First, as shown in Fig 3a, a substrate **50** is provided. Secondly, as shown in Fig 3b, a cathode layer **52** is deposited on the substrate **50**. Further, as shown in Fig 3c, a dielectric layer **54** is deposited on the cathode layer **52**, and an opening **53** is positioned in the dielectric layer **54** to expose the cathode

layer **52**, wherein the opening **53** has a surrounding region **55**. Furthermore, as shown in Fig 3d, a gate layer **56** is deposited on the dielectric layer **54** except the surrounding region **55**. a gate hole **57** is formed after depositing the gate layer **56**.

As shown in Fig 3e, a carbon nanotube photoresist layer **58** is deposited on the gate layer **56** and covering the gate hole **57** using spin coating. The carbon nanotube photoresist layer **58** is preferably composed of positive photoresist or negative photoresist. In this case, the carbon nanotube photoresist layer **58** is composed of negative photoresist and the CNT solution. Furthermore, as shown in Figs 3f to 3g, a CNT emitter pattern **62** is exposed by mask **60** using ultraviolet light and then patterned. In this case, the opening width of the mask **60** is smaller than the width of the gate hole **57** in order to prevent the patterned CNT emitter pattern **62** from contacting the gate layer **56** to prevent short problem. Finally, a thermal process step is executed to form a CNT emitter **64**, as shown in Fig 3h.

As mentioned above, according to embodiment 3 of the present invention, carbon nanotubes are accurately deposited over a large area using spin coating, and an electron-emitting source of triode structure having good properties, and used as CNT-FED, is obtained.

The substrate **50** is preferably made of glass. The cathode layer **52** or the gate layer **56** is preferably composed of electric conductors such as silver. The above thermal process preferably adopts a sintering step.

<u>Embodiment 4</u>

Figs. 4a to 4h are sectional views showing a process for manufacturing an electron-emitting source of triode structure using electrophoretic deposition (called EPD).

First, as shown in Fig 4a, a substrate **70** is provided. Secondly, as shown in Fig 4b, a cathode layer **72** is deposited on the substrate **70**. Further, as shown in Fig 4c, a dielectric layer **74** is deposited on the cathode layer **72**, and an opening **73** is positioned in the dielectric layer **74** to expose the cathode layer **72**, wherein the opening **73** has a surrounding region **75**. Furthermore, as shown in Fig 4d, a gate layer **76** is deposited on the dielectric layer **74** except the surrounding region **75**. a gate hole **77** is formed after depositing the gate layer **76**.

As shown in Fig 4e, a sacrificial layer **78** is deposited on the surface of the gate layer **76** and the surrounding region **75**, wherein the gate hole **77** and the cathode layer **72** are exposed. Because the sacrificial layer **78** defines the position where CNT formed on the cathode layer **72,** and prevents CNT from being absorbed into the sidewalls of the gate hole **77** or the surface of the gate layer **76** during electrophoretic deposition step, it successfully solves the leakage current or short problems caused by the residue of the CNT left on the dielectric layer **74** or the gate layer **76** after thermal process step.

As shown in Fig 4f, an adhesive layer **80** is deposited in the gate hole **77**. Further, CNT is deposited on the adhesive layer **80** using an electrophoretic deposition step. In this case, the electrophoretic deposition preferably adopts cathode electrophoretic deposition, anode electrophoretic deposition, or suspensing electrophoretic deposition.

Fig. 5a is a sectional view showing cathode electrophoretic deposition. In this Fig. 5a, **90** and **94** show a metal electrode and an organic solvent system, respectively. Because of a cathode layer **72** is connected with negative electrode, a positive CNT particle 92 is attracted to deposit on the adhesive

layer **80**. Further, Fig. 5b is a sectional view showing anode electrophoretic deposition. In this case, because the cathode layer **72** is connected with positive electrode, the negative CNT particle **92** is attracted to deposit on the adhesive layer **80**. Fig. 5c is a sectional view showing suspensing electrophoretic deposition. Water solution system **96** preferably uses distilled water or deionized water as solvent, neither of which interact with sacrificial layer **78**.

Lastly, a thermal process step is executed, and the sacrificial layer **78** is removed to form a CNT emitter **82**, as shown in Fig 4g.

As mentioned above, according to embodiment 4 of the present invention, carbon nanotubes are accurately deposited over a large area using electrophoretic deposition, and an electron-emitting source of triode structure having good properties, and used as CNT-FED, is obtained.

The substrate **70** is preferably made of glass. The cathode layer **72** or the gate layer **76** is preferably composed of electric conductors such as silver. The sacrificial layer **78** is preferably composed of photosensitive materials such as photoresists, peelable materials such as hydrophilic materials and lipophilic materials, soluble materials, sinterable materials, or etchable materials. The above thermal process preferably adopts a sintering step.

Finally, while the invention has been described by way of example and in terms of the preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art. Therefore, the scope of the appended

claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.